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A Process for Processing OFDM-Signals Received Simultaneously by a Multi-Antenna System

The invention relates to a process according to the preamble of the Main Claim.

In modern digital technology, so-called OFDM-systems (Orthogonal-Frequency-Division Multiplex) or COFDM-systems (coded OFDM) are used for data transmission (sound, video or other data). In accordance with this principle, prior to transmission the digital data stream is split via a transmitter network into a plurality of sub-signals, each of which is transmitted separately on an individual carrier. In the so-called DVB-T-system (Digital-Video-Broadcasting, terrestrial), which also serves for the transmission of data of a general type, 1705 or 6817 individual carriers are used for example. In the receiver these items of subsidiary information are recombined to form a complete item of information of the transmitter-end digital data stream.

These OFDM-systems are standardized in terms of the transmitting-end conditioning and receiving-end recovery of the data (for example in the DAB-standard ETS 300401 for DAB and in the standard ETS 300744 for DVB-T). It is a common feature of these OFDM-systems that at the receiving end the high-frequency signal received by an antenna is demodulated in an OFDM-demodulator, preferably after conversion into an intermediate frequency, and in this way the associated I/Q-values are acquired for each individual carrier. In a so-called pilot-tone-corrected OFDM-system, as used in DVB-T, a channel correction value is determined simultaneously from the co-transmitted pilot tones. For each individual carrier, each I/Q-value is complexly multiplied by the relevant channel correction value. This ensures that all the carriers have constant amplitudes, possible breaks in amplitude of individual carriers of the overall reception band, caused for example by multipath

reception disturbances, being appropriately compensated and corrected.

In such systems, in addition to the individual data, it is also common practice to transmit so-called confidence values and thus to influence the further processing of the acquired digital values in so-called soft-decision processes. These two known possibilities of correcting the I/Q-values via the channel correction or the obtained digital values through the confidence values are state of the art in receiver technology.

To improve the signal/noise ratio, in particular for the mobile reception of such OFDM-signals, it is known to provide a multi-antenna system with two or more antennae and correspondingly assigned, separate receiving channels, and to combine the analogue received signals in the receiver in the HF- or IF-plane of this plurality of receiving channels. The analogue signals of the individual receiving channels are added, having been weighted in frequency-dependent manner, for example as a function of the received power. Here however not only the useful signals but also the noise components are combined, which in principle can even result in an impairment of the signal/noise ratio compared to the most favourable receiving channel for the relevant sub-band. These analogue combining processes also require a very high outlay and follow the relevant channel properties only relatively slowly. In the case of frequency-selective addition, they have only relatively flat selection curves, i.e. sharp breaks in the receiving frequency range cannot be corrected.

Therefore the object of the invention is to indicate a process for combining OFDM-signals received simultaneously by a multi-antenna system which avoids these disadvantages and leads to a distinct improvement in reception.

Commencing from a process according to the preamble of the Main Claim, this object is achieved by the characterising features of the Main Claim. Advantageous further developments are described in the sub-claims.

In accordance with the invention, in each individual receiving channel of the multi-antenna system, the values for channel correction or confidence anyhow acquired therein according to the relevant standard are used for a corresponding weighting of the demodulated I/Q-values. In the DAB-system, in which the confidence values are determined in known manner, these can be used in accordance with the invention to add the relevant I/Q-values in an appropriately weighted manner and thus, from the relevant receiving branches having a good signal/noise ratio for the received signal, to obtain a corresponding mean value of the individual received signals of the multi-antenna system, which is particularly advantageous for the mobile reception of DAB-signals where, due to the properties of the transmission channel, a more difficult reception situation exists than in the case of stationary reception. In this way fading disturbances can be corrected.

It is particularly advantageous to perform this correction as a function of the channel correction values as provided in the DVB-T-system. Here again, mobile reception with a good signal/noise ratio is possible, this weighted evaluation of the received signals in the individual receiving channels facilitating a particularly simple analysis algorithm.

In the following the invention will be explained in detail in the form of two exemplary embodiments making reference to schematic drawings.

Figure 1 is the fundamental circuit diagram of a receiving arrangement for processing pilot-tone-supported OFDM-

signals in which the signals of the individual carriers of the multi-antenna system are digitally combined upstream of the decision device. The received multicarrier OFDM-signals are received via a plurality of antennae A1 to An and can optionally be converted into a suitable intermediate frequency via individual receivers E1, E2 to En. All the receivers E1 to En are set at the same receiving frequency and for simplicity the down-conversion into the intermediate frequency optionally can be performed using a common oscillator. Then, in each of the n receiving channels, the demodulation of the OFDM-signals is in each case performed in separate demodulators D1 to Dn and at the same time the associated channel correction values are also acquired, these being a gauge of the level of the individual carriers of the multicarrier system and thus also a gauge of the probability that the symbol transmitted with this carrier is correct.

The I/Q-values available for each individual carrier at the output of the demodulators are fed to a time synchronisation device S, in which possible time offsets of the total number n of I/Q-signals are corrected by corresponding delay devices so that the I/Q-values of corresponding carriers occur simultaneously at the output of this time synchronisation device S, which values are then fed to a processing device R and processed therein as will be described in the following. The time synchronisation can be performed using synchronisation flags known in association with OFDM demodulators.

Before the I/Q-values, thus conditioned in known manner, are reduced to individual bits in the decision (demapping) device M, in the processing device R they are complexly multiplied by a value k proportional to the reciprocal value of the relevant channel correction, and thus are weighted. This weighting is firstly performed individually for each I/Q-value for all n receiving channels. The I/Q-

values are thus weighted particularly high if they are changed as little as possible by the channel correction. Then all the mutually assigned I/Q-values are added and divided by the sum of all the weights. Figure 2 illustrates this type of weighting and addition for two antennae A1 and A2. Of the total of 1705 or 6817 individual carriers of the system, at the frequency f1 the received carrier is received only with a reduced amplitude via the antenna A1 due to fading. This is expressed by the reciprocal value k1 of the channel correction obtained for this receiving channel. The carrier at the frequency f1 is thus weighted with a relatively low weight, for example only with the channel correction value 2, while the carriers in the range below and above the frequency f1, which are received at the full level, are weighted very high, for example with the weight 10. In the case of the antenna A2 this low weighted receiving range lies at a different location at the frequency f2.

When the I/Q-values, differently weighted in this way with for example 2 and 10 in the f1 range, are now added and finally divided by the total number of all the weights (in the example 12), a mean value is obtained which has a constant good reception value over the entire frequency range. The averaged I/Q-values thus obtained in the processing device R are then fed to the decision device M and further analyzed therein in known manner. Optionally, the confidence of the information can also be calculated therein. Then the data are further processed in a conventional Viterbi-decoder V with soft decision.

Figure 3 illustrates an exemplary embodiment of a receiving arrangement for processing OFDM-signals in a multi-antenna system by digital combination downstream of the decision device M. In many cases the I/Q-values are available for further processing not upstream of the decision device but only downstream of the decision device M, which in this

case for example is integrated in the demodulator D1 for each individual receiving channel. Thus the data words reduced to individual bits are already available at the output of the demodulator and indeed together with the confidence values which have likewise been calculated in the decision devices M1 to Mn and which, following the time synchronisation in the time synchronisation device S, are weighted and further processed in the processing device R as follows.

Each individual data word of the n receiving channels is reduced to the original I/Q-values using a suitable algorithm. The thus obtained, corresponding I/Q-values are then complexly multiplied by the value of the relevant confidence information, whereupon all the thus weighted I/Q-values are added again as described in association with Figure 2 and then divided by the number of all the weights. When the I/Q-values have been reduced to the data bits, the thus determined mean value of all the I/Q-values is then fed again to the Viterbi-decoder with soft decision V and further processed.